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Forest Cover Change in USAID and Control Areas

A Preliminary Evaluation and Report to USAID and Partners

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Executive Summary

USAID activities in Madagascar within the context of the National Environmental Action Plan (NEAP) include a comprehensive package aimed at ensuring biodiversity conservation. They include the following activities aimed at mitigating the impact of agriculture on forests, and improving the management of protected areas.

In order that USAID evaluate its intervention in Madagascar, indicators of the impact of these activities on forest are required. USAID thus requested PAGE to evaluate the rates of change of forest cover between 1994 and 1999-2000 in the two USAID priority areas, the corridors between Zahamena-Mantadia and Ranomafana-Andringitra. In order that we could **evaluate the potential effects of USAID and other NEAP actions in the priority corridors**, we also asked the consultants to measure forest cover change rates in a control case, the sector for forest between the two USAID corridors, centred around Anosibe-an'Ala (see map), where no USAID action occurs and there is a very limited NEAP presence.

This report presents preliminary results of these studies, including detailed methodology and breakdown of results by corridor sector, altitude band and sample area.

Further validation of these results is necessary before any firm conclusions can be drawn about why the rates of change vary between areas. The detailed results of these validation studies will enable us to evaluate further the extent to which particular conservation strategies (agricultural intensification, community forest management, protected areas), socio-economic factors (population density, poverty, access to markets), and ecological factors (slope, exposure, precipitation) are linked to rates of forest change.

Specifically, these preliminary results address two areas of particular interest:

1. The comparison of rates of forest change in areas where USAID is working to those where is is not
2. Evaluation of which parts of the forest (specifically which altitudes) are most under pressure.

The initial results suggest the following potentially **very significant conclusions**:

- **Forest is disappearing much more rapidly in areas where USAID is not intervening.** Overall forest loss in the Mantadia-Zahamena corridor over the study period was about 2.2 % (a total of 108 km^2), and in the Ranomafana-Andringitra corridor was about 3.5% (a total of 78 km^2). In the study corridor, between the two USAID priority areas, 6.7% of forest was lost, representing about 145 km^2. This is about twice the rate of forest loss in the two USAID priority areas. It is premature to attribute this difference purely to **USAID activity**, but that is **likely to be one important factor**. We will analyse this issue in more detail, in particular the extent to which the differing rates of

forest loss in the three study areas can be linked to socio-economic factors, presence of protected areas or other forest conservation activities etc..

- **Forest is being lost very rapidly at the lowest altitudes.** This is particularly marked in the control corridor and Ranomafana-Andringitra. There is now no forest in the control site below 400 m- it was all already cleared before 1994, and there is hardly any (24 km^2) left below 800 m. In the Ranomafana-Andringitra corridor, the forest below 400 metres experienced the greatest percentage loss (17% over six years, equivalent to complete elimination in 25-40 years if no action is taken) of any zone in any of the three corridors studied. The actual surface area of this forest type is rather low, so the high percentage loss rate does not represent a large area; however, as we know, low altitude forest is probably the most important for biodiversity. Thus this result strongly reinforces the conclusion that **lowland forest should be the highest priority for conservation action**. Even in the Zahamena-Mantadia corridor, rates of loss of forest are much higher at the lowest altitudes than at mid-altitude.
- **A larger area of forest was lost (108 km^2) in the Zahamena-Mantadia corridor corridor than in Ranomafana-Andringitra (79 km^2).** However the Ranomafana-Andringitra corridor contains less forest, so the proportion of forest loss is higher in this corridor than in Zahamena-Mantadia.
- **Forest at high altitudes has also been lost at a disproportionately high rate in the control corridor compared to the USAID focal corridors.** The rate of high-altitude forest loss in the USAID corridors is low, possibly due to the control of wildfire in these corridors through USAID and other project interventions. This forest type is unlikely to have been cleared for cultivation, but is often composed of plant species that are very vulnerable to fire, especially during dry conditions.

We should underline again that these results are preliminary and should not be used other than as general indications.

Please contact us if you require further amplification or explanation of these results.

I - Introduction

USAID activities in Madagascar within the context of the National Environmental Action Plan (NEAP) include a comprehensive package aimed at ensuring biodiversity conservation.

In order that USAID evaluate its intervention in Madagascar, indicators of the impact of these activities on forest are required. USAID thus requested PAGE to evaluate the rates of change of forest cover between 1994 and 1999-2000 in the two USAID priority areas, the corridors between Zahamena-Mantadia and Ranomafana-Andringitra. In order that we could **evaluate the potential effects of USAID and other NEAP actions in the priority corridors**, we also asked the consultants to measure forest cover change rates in a control case, the sector for forest between the two USAID corridors, centred around Anosibe-an'Ala (see map), where no USAID action occurs and there is a very limited NEAP presence.

This report presents preliminary results of these studies, including detailed methodology and breakdown of results by corridor sector, altitude band and sample area.

II - Technical description of methods and results

II - 1 Methods

The forest corridors selected for the evaluation include the two main areas of USAID intervention in the NEAP, those between Zahamena and Mantadia (northern corridor) and Ranomafana- Andringitra (southern corridor). The area of forest selected for a control was an area of forest between these corridors, centred around the area of Anosibe-an'ala (control corridor).

The key hypotheses for testing during this study were:

- Forest is being lost more quickly outside USAID areas of intervention than within them
- Forest is being lost more rapidly in the Ranomafana-Andringitra corridor than in the Zahamena-Mantadia corridor
- Forest is being lost more quickly to the east of the corridors than to the west
- Forest is being lost more quickly in lowland forest (below 800 m) than in forest above this)

In the northern and southern corridors, area, the following USAID-funded interventions occur or have occurred during the life of the NEAP (since 1992/3):

Since 1998, LDI have been conducting a program of landscape-level conservation, particularly agricultural intensification and support to conservation-friendly enterprises, in both the northern and southern corridors. LDI has specific intervention zones in both corridors, identified on maps;

Support to Integrated Conservation and Development Projects (ICDPs) in Ranomafana, Zahamena and Andasibe-Mantadia (see maps). ANGAP are now the official operators for all three protected areas, since 1999.

Other NEAP and para-NEAP activities related to forest conservation occurring in the northern and southern corridors include:

- WWF - Madagascar are conducting an ICDP in the Parc Nationale Andringitra-Réserve Spéciale Ivohibe region (southern corridor)
- GTZ and Cooperation Suisse have conducted a program to study and reduce the amounts of tavy in the region of Beforona, in the southern part of the northern corridor
- Cooperation Française, through CIRAD, have been conducting a study of forest use and land tenure in the area around Didy.
- CCD-Namana implementing community forest conservation actions near Ambohimahamasina, southern corridor
- WWF Projet Cadre d'Appui Forestier, work to develop community forest activities in the area near Tolongoina in the southern corridor

By contrast, in the control corridor, the only NEAP-related forest conservation measure implemented is a community forest at Ankeniheny.

II-1-1 Description of the data sets used

Landsat Thematic Mapper (TM) data, with a spatial resolution of 28.5 meters, were used for all analyses. The dates of the images used are shown in table 1.

Table 1 Satellite image information

Location	Acquisition Date	Path/Row
Zahamena	8-April-1993	158 / 72
Zahamena	19-April-2000	158 / 72
Mantadia	21-November-1994	158 / 73
Mantadia	19-April-2000	158 / 73
East side of southern corridor	30-August-1993	158 / 75
East side of southern corridor	11-November-1999	158 / 75
West side of southern corridor	6-September-1993	159 / 75
West side of southern corridor	17-October-1999	159 / 75
Control Corridor	21-November-1994	158 / 74
Control Corridor	19-April-2000	158 / 74

For the USAID focal corridors, all of the 1999 and 2000 images were ortho-rectified with a published accuracy of 50 meters root mean square error (RMSE) or better. The other images had only systematic corrections applied. This created problems of co-registration because it was not practical to ortho-rectify the 1993/94 images and therefore only simple image warping using control points could be done to register the two data sets. This is described in more detail in the methods section.

For this study, forest was loosely defined as an area of trees greater than 7 meters in height with greater than 70% crown closure. Since no ground verification data were available this definition of forest was loosely applied using visual methods based on the experience of the consultant. Only two classes were used, forest and non-forest. With no ancillary data it was impractical to expect sufficient accuracy if more classes (such as secondary forest) were used. Due to the relatively short period between the two time periods used in this study the only change classes identified were; forest-to-forest, non-forest-to-non-forest, forest-to-non-forest, and obscured. The change class non-forest-to-forest was not identified because it was presumed that detection of such a class could not be done reliably and from the consultants experience it was unlikely that a significant area of that class was present. The "obscured" class included areas that were covered by clouds or shadows. Obscured areas were not used during the analysis.

The software package used for all processing and visualization was ENVI (Research Systems Inc., Boulder, Colorado). ENVI is a powerful image processing system with the capability to carry out all of the tasks necessary for this study.

Two types of images were created during this study. The first was a forest cover image that was used to provide the area covered by forest within the two study areas during the 1993/94 time period. The other image was a change image that showed the areas that changed from forest-to-non-forest. Although it is possible (and sometimes preferred) to only create a change image since that provides the four change classes (forest to forest, non-forest to non-forest, forest-to-non-forest, and obscured) it was decided that a more accurate result could be provided given the restricted time available for analysis using the forest cover and forest change images. The train of thought used for this decision was that a more accurate classification of forest cover could be determined using a single date image and the change class of forest-to-non-forest could more easily and accurately be delineated if that was the only class of interest using the multi-date image.

The forest cover map was created with supervised classification methods using the TM images acquired in 1999/2000. These images were used because of their high quality. To calculate forest cover for the 1993/94 time period the area of the change class forest-to-non-forest was added to the forest cover class for each image location.

To create the forest image a series of training areas (samples from the satellite image) representing the forest, non-forest, and obscured classes were delineated visually. Next, these training areas were input into a maximum likelihood algorithm (MLC) and the output from this was an image of forest, non-forest, and obscured. The accuracy of the forest estimate is probably on the order of +/- 10 percent at a 95% confidence level. This estimate is based solely on the consultants experience and not on a reliable assessment of accuracy.

The creation of the forest cover change image was carried out in several steps. The steps were:

- Preprocess the images to create image pairs
- Select training sites and run a supervised classification
- Eliminate all pixel clusters with less than 9 pixels
- Update the obscured class to only include pixels visible on both dates
- Mosaic the change and forest images for each corridor
- Calculate statistics and output the results

II-1-2 Preprocess the images

Before the analysis could be started the images had to be preprocessed to put them into the Oblique Mercator projection that is used throughout Madagascar and to co-register them to minimize image-to-image offsets. The 1999 and 2000 images were used as the reference images since they had been ortho-rectified and they had acceptable errors. The early-date images (1993/94) were registered to the 1999/2000 images by selecting points that could be seen on both images and then warping the early-date image to fit the late-date image. Second degree polynomial warping was applied. This resulted in a moderately good image-to-image fit but the positional errors were greater than one would hope for with this type of study. These errors resulted because the 1999/2000 images were corrected using 3-dimensional data (a digital elevation model) followed by a non-linear projection (UTM to Oblique Mercator) and the warping process employed by the consultant used only 2-dimensional data. A solution to this problem would have been to have the early date images ortho-rectified using the same procedure used for the late-date images but this was not possible given the time restraints of the project.

The images from the two dates for each location (path/row) were then combined into one multi-date image. For example, when the two images were both TM images the resulting image had 12 bands; 6 bands from the early date image and 6 bands from the late date image. Only TM bands 1,2,3,4,5,7 were used. For the TM/MSS combination the MSS data were resampled to a pixel size of 28.5 meters using a nearest neighbor resampling. Since the MSS images only have four bands, the resulting multi-date image had 10 bands (6 from the TM image and 4 from the MSS image). This resulted in 4 multi-date images, one for each path / row location.

II-1-3 Select training sites and run supervised classification

Standard supervised classification methods were used to classify the different change classes.

Training sites are regions (generally with 100 or more pixels) on the satellite image that represent a particular class such as forest-to-forest. The training sites are used to generate statistics that are used to identify all of the pixels in the image. For example, a training site is selected to represent the forest-to-forest and then statistics from that training site is used to identify other forest-to-forest pixels in the satellite image. Once enough training sites are selected to adequately represent the classes one wants to generate, an algorithm is run to classify each pixel in the satellite image.

After a run, the results were inspected and then if necessary training sites were added or removed and the classification algorithm was re-run. This process was repeated until an acceptable result was obtained. The result of the supervised classification was an image with each pixel classified as one of the change classes.

At the beginning of this study it was envisaged that the consultant would visually inspect the classification and then manually modify the forest-to-non-forest class to correct classification errors. Unfortunately, there was not sufficient time to do this for the two corridors so no adjustments were made to the automated classification results.

II-1-4 Eliminate small pixel clusters

Because of errors inherent with this kind of satellite image analysis it is a common practice to post-process the classified image by removing small clusters of pixels that likely are a result of misclassification. A common cause of these errors comes from the fact that the images are not perfectly co-registered. For this study, an algorithm was used that eliminated any group with 9 or fewer connected pixels. The algorithm considered 8-neighboring pixels (pixels directly above, below, left of, right of, and off the corners) to determine if one pixel was connected to another.

II-1-5 Update the obscured class

The obscured classes for the forest cover image and the forest change image were updated to be identical for both images. This was done by combining the obscured classes from the forest and forest change images and then replacing the original obscured class with the combined class. This assured that only those pixels not classified as obscured in either the forest map or the change map were included in the analysis.

II-1-6 Mosaic images

After the classification results were finished, the images within a corridor were mosaiced to create a continuous image for each corridor. Unfortunately, the northern portion of the southern image for the Zahamena – Mantadia corridor was truncated which resulted in a gap between the northern and southern images. This gap is obvious in Figure 1. In the Ranomafana – Andringitra corridor there was significant overlap between the two images and a decision was made by the consultant to have the eastern image take precedence over the western image during the mosaic processing. In other words, in the overlap portion of the mosaic the eastern image covered the western image.

II-1-7 Calculate statistics

The last step was to calculate statistics for each corridor. Since the time periods between the early and late-date images were different for each image pair a mask was created to identify which image was used to create the different portions of the mosaic. This allowed statistics for each image pair to be calculated by overlaying the forest cover and forest change images with the respective masks. Statistics were also calculated for the east and west sides of each corridor using a mask created by visually approximating a north-south centerline through each corridor.

The following formula was used to calculate the rate of change from forest to non-forest: (Note: T1 is the early date)

For each image:

% Forest loss = Forest loss / Forest T1 * 100

Annual forest loss = % Forest loss / ((2nd date - 1st date[in days]) / 365)

Weighted % annual loss = Annual forest loss * (Forest T1 / Sum of Forest T1 for both images)

For the average forest loss for the corridor:

Average annual forest loss = Sum of the weighted % annual loss for both images

II-1-8 Calculation of forest loss by elevational sector

The elevation data were derived from gridding (converting from vector to raster) the contour layer from the BD500 series available from FTM into 100-meter cells. No attempt was made to correct the BD500 data; it was used "as is".

II - 2 Results

The results from this study are presented in Tables 1-9, and on figures 1-3. Figures 1-3 show that broadly speaking, forest loss was very patchy and mostly restricted to small areas, particularly in the USAID corridors. In the Zahamena-Mantadia corridor, (Figure 1) the most concentrated areas of forest loss were around the national parks of Zahamena and Mantadia, in mid-altitude forest; forest loss in lowland forest is more widespread. In the Ranomafana-Andringitra corridor (Figure 2), forest has been lost more-or-less equally along the eastern fringe of the forest.

FOREST COVER LOSS IN MANTADIA-ZAHAMENA CORRIDOR BETWEEN 1993/94 AND 1999/2000

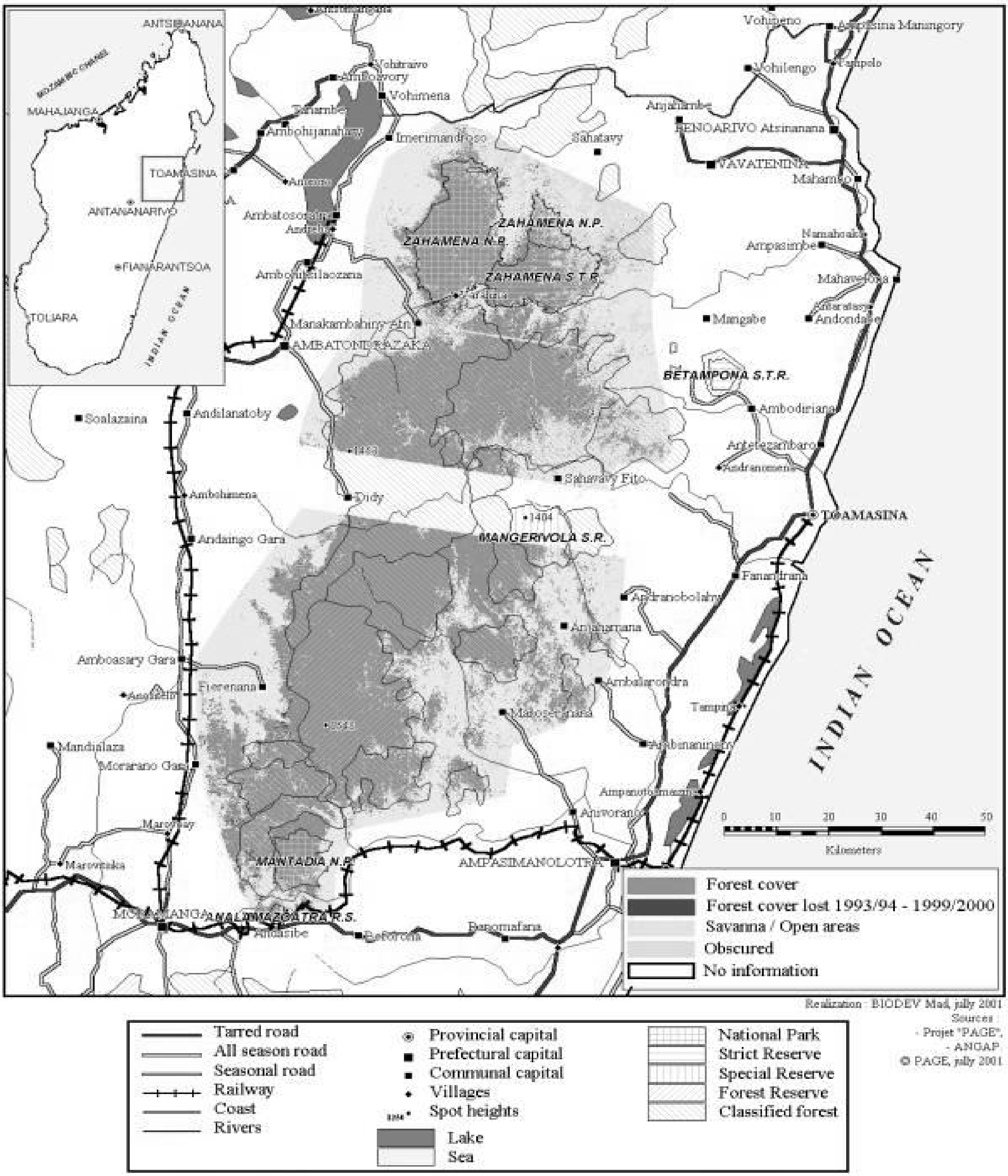

Figure 1 Forest cover loss in the Zahamena-Mantadia Corridor 1993/4-1999/2000.

FOREST COVER LOSS IN RANOMAFANA - ANDRINGITRA CORRIDOR BETWEEN 1993/94 AND 1999/2000

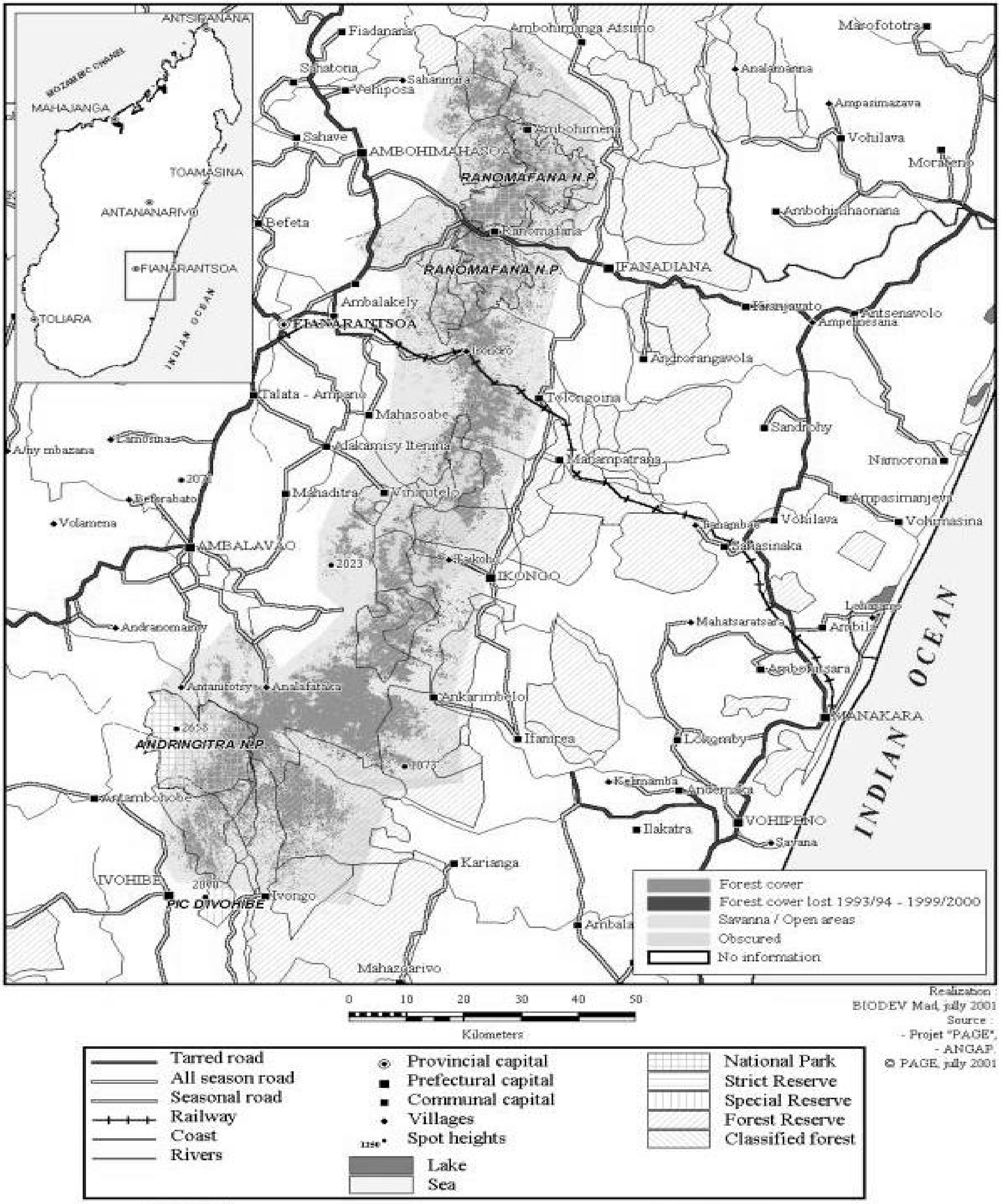

Figure 2: Forest loss in the Ranomafana-Andringitra corridor 1993/4 - 1999-2000

FOREST COVER LOSS IN ANOSIBE AN'ALA - RANOMAFANA CORRIDOR BETWEEN 1993/94 AND 1999/2000

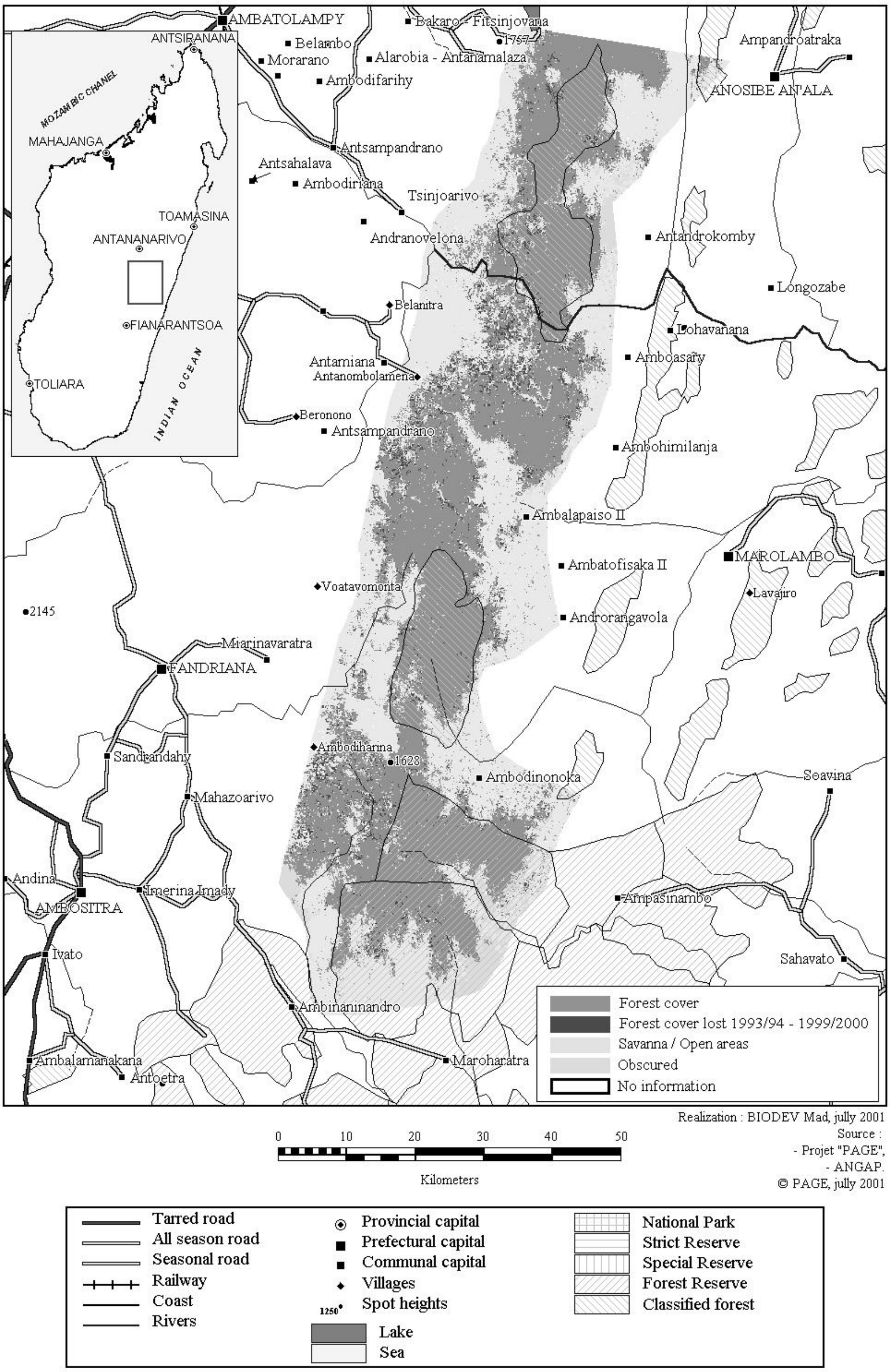

Figure 3: Forest loss in the Anosibe an'ala forest corridor, 1993/4-1999/2000

Forest loss in the control corridor was more widespread and covered a larger range of sites.

II – 2 – 1 Overall cover change estimates

Table 1 shows that overall rates of forest cover loss were highest in the control corridor, moderate in the southern corridor and lowest in the northern corridor. The actual surface area of forest lost was lowest in the southern corridor, as there is less forest remaining in this corridor compared to the northern corridor.

Table 2 Summaries of forest loss in the three corridors in eastern Madagascar 1993/4 – 1999/2000

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4 – 1999/2000	Percentage forest lost 1993/4 – 1999/2000
USAID Priority corridors	Zahamena – Mantadia corridor	**4,874 km²**	**109 km²**	**2.2%**
	Ranomafana – Andringitra corridor	**2,383 km²**	**94 km²**	**3.8%**
Control corridor		**2,027 km²**	**145 km²**	**6.7%**

Table 2 and Figure 4 show the range of estimates of forest loss in the three corridors given the estimated 95% confidence interval of 15%. The fact that the error ranges for the three corridors do not overlap suggests that the percentage loss rates are genuinely different, and that forest is being indeed lost proportionately much more rapidly in the control corridor than in the northern and southern corridors, and more rapidly in the southern than the northern corridor. However this does not diminish the significance of the fact that despite the lower rate of loss in the northern orridor, more forest is being lost in this area than in the southern corridor.

Table 3 Forest loss estimates for the three corridors with 95% confidence interval calculations

	Total Forest => Non-Forest + 15%	Total Forest => Non-Forest – 15%	Weighted Forest => Non-Forest /year + 15%	Weighted Forest => Non-Forest /year – 15%

USAID Priority corridors	Zahamena-Mantadia corridor	2.5 %	1.9 %	0.4 %	0.3 %
	Ranomafana	4.4%	3.2 %	0.7 %	0.5 %
Control corridor		7.7 %	5.7%	1.4	1.1 %

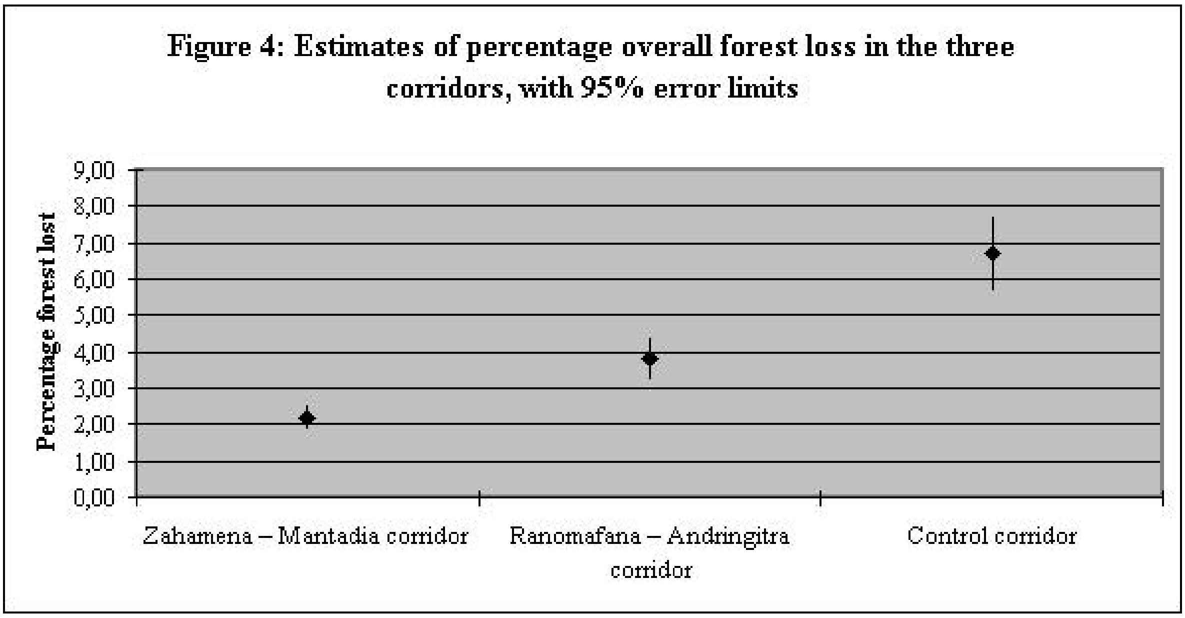

Figure 4: Estimates of percentage overall forest loss in the three corridors, with 95% error limits

Tables 3 and 4 show that for the two corridors where USAID activity is concentrated, loss of forest was greater on the eastern than the western side. The opposite was true in the control corridor, and indeed it seems that much of the forest lost comes from the western side of the control corridor. The reasons for this are as yet unclear.

Table 4 Forest loss on the western side of the three corridors

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4 - 1999/2000	Percentage forest lost 1993/4-1999/2000	Weighted % Forest => Non-Forest/year
USAID Priority	Zahamena - Mantadia corridor	2,742	56	2.0%	0.3%

	Ranomafana – Andringitra corridor	1,388	38	2.6%	0.4%
Control corridor		1,023	95	8.5%	

Table 5 Forest loss on the eastern side of the three corridors

		Area of forest remaining in 1999 - 2000	Area of forest lost 1993/4-1999/2000	Percentage forest lost 1993/4-1999/2000	Weighted Forest => Non-Forest/year
USAID Priority corridors	**Zahamena - Mantadia corridor**	2,132	**52**	**2.4%**	**0.4%**
	Ranomafana-Andringitra corridor	995	57	**5.4%**	**0.9%**
Control Corridor		1000	50	4.8	

II - 2 - 2 Altitude analysis

Tables 5-8 show the rates of loss of forest in each of four altitudinal bands in the three forest corridors. These altitudinal bands were chosen as they represent approximate divisions of the forest into distinct ecological types, with different biodiversity components and values.

Table 6 Forest loss in the 0-399 m altitudinal band in the three corridors

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4-1999/2000	Percentage forest lost 1993/4-1999/2000
USAID Priority corridors	**Zahamena - Mantadia corridor**	98	3	3.3%
	Ranomafana - Andringitra corridor	63	13	17.3%
Control corridor		No forest	No forest	No forest

Table 7 Forest loss in 400-799 m altitudinal band

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4-1999/2000	Percentage forest lost 1993/4-1999/2000
USAID priority corridors	Zahamena - Mantadia corridor	1,090	43	3.8%
	Ranomafana - Andringitra corridor	737	42	5.4%
Control corridor		24	2	9.0%

Table 8 Forest loss in 800-1199 m altitudinal band

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4-1999/2000	Percentage forest lost 1993/4-1999/2000
USAID Priority	Zahamena - Mantadia corridor	3,144	60	1.9%
	Ranomafana - Andringitra corridor	1,039	21	2.0%
Control corridor		481	44	8.4%

Table 9 Forest loss in 1200-1599 m altitudinal band

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4-1999/2000	Percentage forest lost 1993/4-1999/2000
USAID Priority corridors	Zahamena - Mantadia corridor	551	2	0.4%
	Ranomafana - Andringitra corridor	517	18	3.3%
Control corridor		1,343	79	5.6%

Table 10 Forest loss in 1599 m + altitudinal band

		Area of forest remaining in 1999-2000	Area of forest lost 1993/4 – 1999/2000	Percentage forest lost 19993/4- 1999/2000
USAID Priority corridors	Zahamena – Mantadia corridor	No land above 1599 m		
	Ranomafana – Andringitra corridor	2	0.03	0.1%
Control corridor		174	19	10.0%

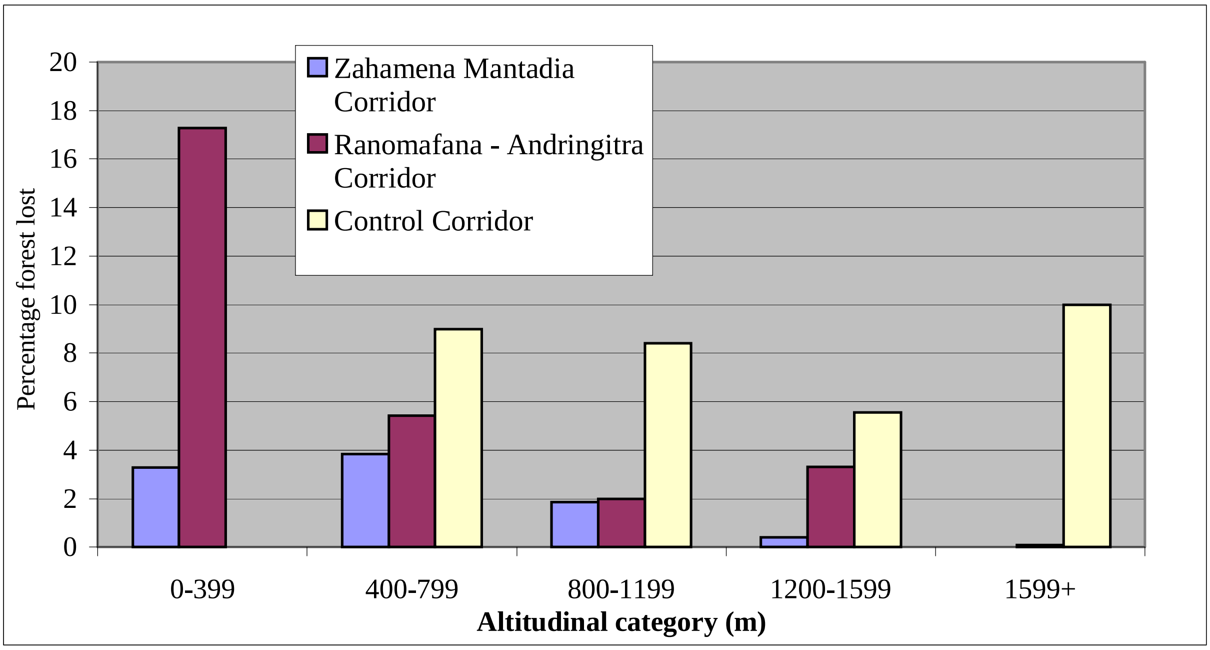

Figure 5: Proportion of forest lost within altitude categories in the three corridor1993/4 -1999/2000

In relation to the area of forest left in each corridor, forest is being lost in all areas proportionately most rapidly in the lower altitudinal band (Figure 2). This is especially true of the Ranomafana-Andringitra corridor. It appears that all the forest in this corridor in this altitudinal band will be lost in the next 40-50 years at present rates of loss. In the control corridor, all the forest below 400 m had already been lost before the first of our samples. The rate of loss of lowland forest in the northern corridor is lower but is still the highest of any altitudinal band in this corridor. Mid-altitude forest is being lost in the USAID focal areas proportionately less rapidly, but this is a reflection of the amount of this forest remaining. Forest between 400 and 1600 m is being lost rapidly in the control corridor; at present rates it will disappear in the next 50-100 years. The highest altitude forest in the control corridor is also being lost proportionately very rapidly. Forest at higher altitudes in the southern and northern corridors is better conserved.

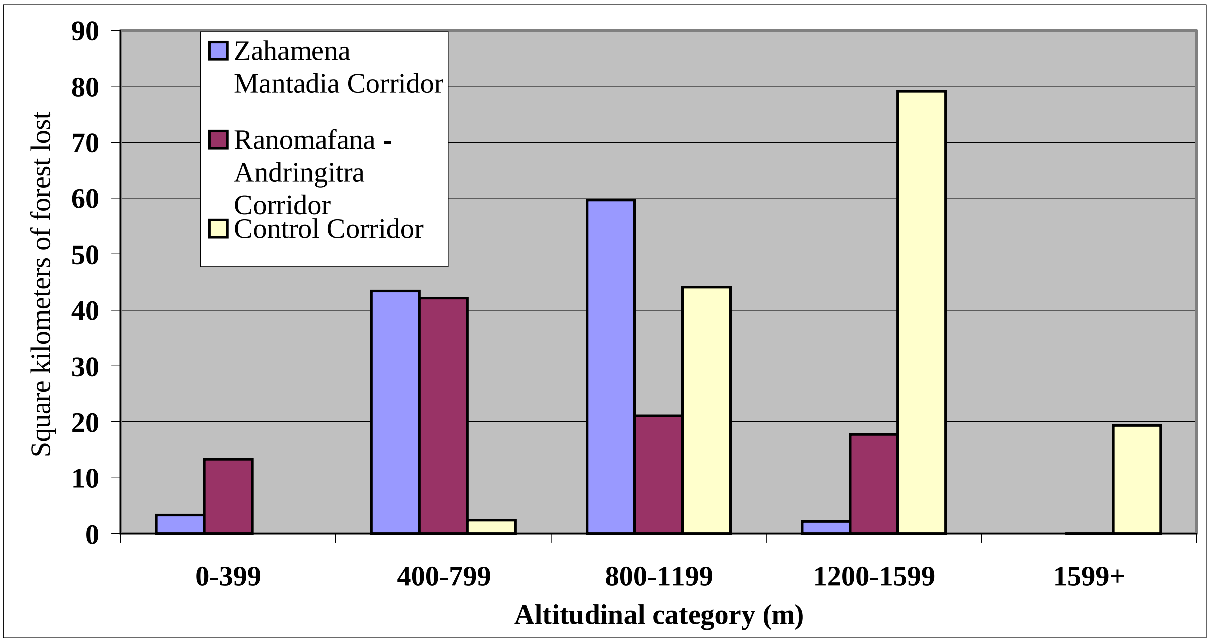

Figure 6: Surface area of forest lost in different altitude categories in the three Corridors, 1993/4-1999/2000

In Figure 6 the actual surface areas of forest lost are compared. This shows clearly two main conclusions; large areas of lowland forest (400-800 m) have been lost frosm the two USAID forest corridors during the study period, and that very large areas of mid-altitude forest, between 800 and 1200 m (Zahamena- Mantadia) and 800-1600 m (Control Corridor) were lost over the period of the study. There was much less forest loss in the Ranomafana-Andringitra corridor at mid-altitudes during this period.

II - 2 - 3 Main sources of error

The accuracy of the results for this study could not be evaluated using reliable methods. This was due primarily to time constraints. Using the consultant's experience, however, it is expected that the results for all corridors are better than +/- 15% at a 95% confidence interval (see Table 2). The estimation of error will be a principal output of the ground verification process.

A major source of error, particularly for the Ranomafana-Andringitra corridor, is the presence of fairly large areas of cloud in the lowland sectors. It seems very likely that this has resulted in a serious underestimate of the forest loss in this corridor. It also seems possible that there are areas of shifting cultivation in all corridors that occur patchily and are thus poorly resolved in this analysis. It is thus extremely important that verification of the status of the forest near active cultivation borders is made, before these results are confirmed.

III – Conclusions

1 – Methodology

The results from this study provide estimates of rates of deforestation for three corridors in Madagascar. The methods used for the satellite interpretation portion of this study are sound and can be implemented using several different image-processing packages. There are The methods used for this study were selected primarily because of the time limitations imposed on this project. If more time were available other methods would have likely been used. More important than the classification method, however, is the validation of the classification results. If higher accuracy estimates are necessary, it is imperative that a reliable field verification phase be conducted. The lack of such a component in this study significantly degraded the accuracy of the results.

The results from this study should be considered preliminary. Efforts are currently underway to improve the quality of these results through the following activities:

- Validation of forest cover in areas of uncertainty identified in the initial study. These include areas where forest loss is particularly rapid, and areas where soil is thin and tree cover low;
- Improvement of parameters in the forest cover algorithm using the validation results
- Definition of range of variation in forest cover types based on field samples in all three corridors
- Estimation of forest cover change rate error based on field visits to sample sites in all three corridors

2 – Forest loss estimates

The figures in this study show a rate of forest loss that is perhaps lower than that which might be expected, especially in the USAID priority corridors. There are a number of reasons why this result should be regarded with caution:

- The lack of ground verification
- The amount of cloud cover
- The difficulty of imputing cause to the rate and pattern of forest loss- it may be that all the loss has happened within a short period, not over the 6-7 years of this study
- The scale at which loss may happen- it is possible that significant forest loss is being caused by forest clearance at smaller scales than the 28 ha minimum sampling area in this study.

Nevertheless, these results allow us to state the following conclusions clearly:

- **Forest is disappearing much more rapidly in areas where USAID is not intervening**. Overall forest loss in the Mantadia-Zahamena corridor over the study period was about 2.2 % (a total of 108 km^2), and in the Ranomafana-Andringitra corridor was about 3.5% (a total of 78 km^2). In the study corridor, between the two USAID priority areas, 6.7% of forest was lost, representing about 145 km^2. This is about twice the rate of forest loss in the two USAID priority areas. It is premature to attribute this difference purely to **USAID activity**, but that is **likely to be one important factor**. We will analyse this issue in more detail, in particular the extent to which the differing rates of forest loss in the three study areas can be linked to socio-economic factors, presence of protected areas or other forest conservation activities etc..
- **Forest is being lost very rapidly at the lowest altitudes.** This is particularly marked in the control corridor and Ranomafana-Andringitra. There is now no forest in the control site below 400 m- it was all already cleared before 1994, and there is hardly any (24 km^2) left below 800 m. In the Ranomafana-Andringitra corridor, the forest below 400 metres experienced the greatest percentage loss (17% over six years, equivalent to complete elimination in 25-40 years if no action is taken) of any zone in any of the three corridors studied. The actual surface area of this forest type is rather low, so the high percentage loss rate does not represent a large area; however, as we know, low altitude forest is probably the most important for biodiversity. Thus this result strongly reinforces the conclusion that **lowland forest should be the highest priority for conservation action.** Even in the Zahamena-Mantadia corridor, rates of loss of forest are much higher at the lowest altitudes than at mid-altitude.
- **A larger area of forest was lost (108 km^2) in the Zahamena-Mantadia corridor corridor than in Ranomafana-Andringitra (79 km^2).** However the Ranomafana-Andringitra corridor contains less forest, so the proportion of forest loss is higher in this corridor than in Zahamena-Mantadia.
- **Forest at high altitudes has also been lost at a disproportionately high rate in the control corridor compared to the USAID focal corridors.** The rate of high-altitude forest loss in the USAID corridors is low, possibly due to the control of wildfire in these corridors through USAID and other project interventions. This forest type is unlikely to have been cleared for cultivation, but is often composed of plant species that are very vulnerable to fire, especially during dry conditions.

3- Further activities envisaged

This report describes a study that was intended to be the first stage in a larger process of measuring rates of forest cover change in all the USAID priority areas. Three further steps are planned:

- Development of the methodology described here for use in the other USAID focal areas in Madagascar, including the Mahajanga and Diego regions. This process may be more difficult as the key habitat in these areas is dry deciduous forest, which is much more difficult to classify in satellite imagery as it is essentially leafless for eight months a year

- Integration and comparison of the results of this study with other national and international efforts to measure forest cover change in Madagascar.
- Integration of efforts in ground validation of remotely-sensed data.